

# Cross-platform Hypermedia Examinations on the Web

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*The authors developed a multiple-choice medical testing system delivered using the World Wide Web. It evolved from an older, single-platform, locally-developed computer-based examination. The old system offered a number of advantages over traditional paper-based examinations, such as digital graphics and quicker, easier scoring. The new system builds on these advantages with its true cross-platform design and the addition of hypertext learning responses. The benefits of this system will increase as more medical educational resources migrate to the Web. Faculty and student feedback has been positive. The authors encourage other institutions to experiment with Web-based teaching materials, including examinations.*

## INTRODUCTION

The Internet's popularity has risen dramatically in the past year, and no function has grown faster than the World Wide Web.<sup>1</sup> Combining text, graphics, audio, and video in one attractive package, the Web offers Internet novices and experts a path to the best the Internet has to offer.<sup>2</sup> For educators, however, the Web's most tempting capability may be cross-platform hypertext and multimedia. Web browsers (the applications used to access information on the Web) exist for most commonly available platforms, and Web servers send the same information to each client. There is no need to rewrite or recompile a multimedia application for each different platform. Presentation of the information to the user varies slightly based on the type of browser in use, but these differences are generally insignificant. Problems can arise, however, when a user with a text-only browser attempts to access a graphics-filled site; the user may not get all the information. Protocols exist to accommodate text-based browsers accessing a page with inline graphics, but these compromises are not always successful.

Online textbooks have been among the first educational materials to appear on the Web.<sup>3</sup> Many institutions are experimenting with supplementing or even replacing lectures with Web-based materials.<sup>4</sup> Online testing becomes the next step.<sup>5</sup> At Vanderbilt University Medical School, the third-year Pediatrics Clerkship Examination has been presented to students and scored via computer for over two and a half years. Given the

limitations of the multimedia tools we used to develop the test, it was available only on Apple Macintosh computers. Students had to split into two groups to take the exam, due to the limited number of workstations available in one location.

The Web's ubiquity and cross-platform multimedia capabilities became the primary motives behind our decision to extend the Pediatrics examination to the Web.

## SYSTEM DESCRIPTION

The first computer testing system we created took a big step beyond the paper-based system then in use. Before the computerized test, the 60 multiple-choice examination questions were chosen by a faculty member and then typed, printed, and copied by an administrative assistant. Students filled out computer-readable scoring forms (similar to the ones given with standardized tests such as the SAT), which were then taken to data processing, and results were returned within two or three weeks. With the original computer system, students read the questions on the screen and selected their answers with the mouse. Some questions also had associated digital images. After the students finished the examination, a program ran that calculated the scores. We then sent the results to the clerkship director via e-mail. The students did not know their score until the clerkship director notified them later.

The conversion from the old platform to the Web began in November 1994, and VUMC students took their first Web-based Pediatrics examination the following month. In addition to incorporating the features of the old computer system, the Web-based tests include new capabilities. Cross-platform use is the most important of these. Students also see their score immediately upon finishing the test. After the testing period, students may check their choices against the correct answers. Learning responses will be available soon.

The new system also offers benefits to the instructors. Throughout the testing period, an administration page is available where instructors may see a list of all students who have completed the test along with their scores. This Web page also lists each question and the number

of students who answered each question correctly, incorrectly, or skipped it. Instructors can use this for item analysis to tailor future questions. This feature is particularly useful to Pediatrics, since each 60-question Pediatrics exam draws its questions randomly from a much larger pool of questions.

Other than minor problems with server settings, students successfully completed the test. In an effort to generalize the system and make it available for many other departments in the Medical School, first-year students in the Histology course took a twenty-question test. Although the system processed a much larger number of students for Histology, they completed the examination with no problem other than two students with swapped identification numbers in the authentication file.

In those courses without an established pool of questions, teachers create the multiple-choice quiz using their word processor of choice. They produce an ASCII text file which must adhere to a few simple guidelines. At no time does the instructor need to write any HyperText Markup Language (HTML).<sup>6,7</sup> Perl<sup>8</sup> scripts on the server automatically convert this text file to appropriately formatted HTML. The server administrator creates a configuration file and then notifies students of the address for the quiz or examination. The students then authenticate themselves and take the quiz. Authentication currently involves the students' names and identification numbers. For more security, students could be restricted to particular machines, particular time slots for the exam, or assigned passwords.

The Pediatrics Clerkship Examination requires no interaction from faculty members, other than to retrieve the students' scores. The exam is generated with Perl scripts that randomly extract 60 questions from a larger pool of questions. While the pool size is not large, students see the questions only at the end of the clerkship. Administrative staff in Pediatrics provide notification when the next examination is scheduled, the information is entered into a configuration file, and a script runs to generate the questions. The process takes less than five minutes, and there is no reason that a capable (and trusted) staff member in the department could not do the same thing.

## DISCUSSION

The Active Digital Library's (ADL) initial interest in HTML and the Web for education was driven by the ubiquity and cross-platform multimedia capabilities of HyperText Transfer Protocol (HTTP)<sup>9</sup> servers and Web browsers. The same text, graphics, audio, and video files are available to users, regardless of platform. The

server retains only one copy of the information, not multiple copies for each platform. This cross-platform ability eases restrictions on scheduling examinations and obtaining enough available machines for administration of the exam. In fact, the intrinsic distributed nature of the Web allows students to take the exam from anywhere on campus, or, conceivably, in the world. This also presents a security risk, and requires additional levels of security.

The computer system has reduced the amount of work required from administrative personnel and faculty. The system picks the questions and prepares the examination in less than five minutes. With the addition of the course evaluation form to the Web version of the quiz, no paper is involved at all. We need only: (1) someone to monitor the students during the examination; and, (2) the director of the clerkship to check a secured Web page after the examination to retrieve the scores. Course evaluation results are delivered to the clerkship director via e-mail.

We discovered in this experiment with the Web that its protocols tend to produce very granular pieces of information, allowing, and even encouraging, repurposing of the material. Images and text remain separate from one another, readily available for inclusion in another teaching module without altering the suitability for the original purpose. For example, information about pediatric neoplasms presented in a tutorial for students in pathology could be reused in a learning module for students in pediatrics. Authors are also much less likely to "reinvent the wheel," since the addressing scheme of the Web makes information from a server located on the other side of the world just as accessible as the information on the local campus. The pathology tutorial from the previous example could be used by a pediatrics course at another institution. The new teaching module would merely need to point to the pathology tutorial and present the information in a new context.

The lack of content-providers with sufficient computer skills is an important problem in multimedia educational development.<sup>10</sup> There may be many physicians who want to provide educational software, but there are few physicians with sufficient technical expertise to do so. Authoring shells have been one way to allow those with content knowledge to create teaching material with a minimum of computer skills. Those who provide the content are unlikely to use their own creations and, therefore, may not know what the learners need or expect from their programs. Authoring systems are generally written and remain in-house, and certainly reach a very small audience. The Web, on the

other hand, enjoys extremely wide-spread availability, and both providers and users frequently utilize its resources. This familiarity with the Web will allow authors of Web-based learning tools to be more consistent, and, perhaps, to produce material that is more appropriate for their audience.<sup>11</sup>

The ADL is experimenting with a Web-based forms interface to the Pediatrics Examination pool of questions which allows authorized faculty members to browse and edit existing questions, and even add their own. This is no problem for questions that contain only text, but we have no easy way of accepting binary files, such as images or audio clips. The File Transfer Protocol (FTP) interface of Web browsers is, currently, a one-way process: a user can download files from an FTP site, but the user cannot upload them through the Web browser. We have written some preliminary scripts on the Macintosh that utilize AppleScript and the Anarchie FTP program. Faculty members may drag their files onto an icon, and the files are then automatically placed on the Web server. The name of the file is placed on the Clipboard, ready for pasting into the forms interface. This currently works only on the Macintosh, and we have found that even the act of dragging and dropping onto an icon (as opposed to dragging and dropping into the Web browser window) seems confusing to some faculty members.

We may allow professors to create the quiz over the Web itself as one more way to make the process easier. Any professor with a Web browser and sufficient authorization can place questions into the databank. It is no longer the responsibility of one faculty member to write all the questions. Instead, faculty submit the questions at their convenience, and no further human interaction is needed. Most departments will institute review procedures for submitted questions before they allow them to be used in a real examination, but this review can be scheduled regularly and the questions evaluated and accepted or rejected. Rejected questions could be returned to the author for modification. This procedure can also be done with a Web browser.

A final advantage to editing the questions with a Web browser is consistency. The system does not rely on a meticulously formatted text file. Instead, users must enter information into specific spaces, and the system will not accept input that has not been completed. This insistence on consistency of information vastly improves the overall system reliability.

In other educational efforts, we discovered that support of influential faculty members is imperative for the success of any educational technology program.<sup>12</sup> We want to allow faculty members to edit the question

banks through their Web browsers for several reasons: (1) it will provide a familiar interface, and thus will be easier to use; (2) we want to encourage Web use by the content providers so they will have a better feel for how their material should be presented; (3) the Web is increasingly popular, and we want to capitalize on that popularity in order to encourage faculty members to produce improved educational materials.

Another exciting use of the Web (as opposed to a conventional, stand-alone multimedia environment) for the purposes at Vanderbilt is the ability to link to other sites and access information there as easily as accessing information from local servers. Addressing on the Web is accomplished with URLs (Uniform Resource Locators)<sup>13</sup> which allow a single page to refer to documents throughout the Internet. This ability to pull varied pieces of information together from sources all over the world will be particularly useful for learning responses in the examinations that provide them.<sup>14</sup> Authors of questions may include appropriate links for each question, and students can access these links, whether they reside locally or on another campus. This will be useful for exams that are structured for self-review. A good example of a site with learning responses is a quiz to test knowledge of the world of SpiderMan.<sup>15</sup> Despite its frivolous intention, this quiz system is well-done and offers a pleasant interface. Another site that provides learning responses is a tuberculosis quiz at Stanford.<sup>16</sup> Unfortunately, this site does not provide hyperlinks in the learning responses. Perhaps there is not yet enough material on the Web, or, more likely, not enough of a concerted effort among developers of materials such as these to make good use of other sites on the Web.

Our system handles only multiple-choice questions, though true-false examinations could be handled by a multiple-choice question with only two choices. Matching questions could be integrated with some changes in programming, and the system would still remain automated. We have no way, however, of accurately scoring short answer or essay questions using the computer. Faculty must review these answers. There is nothing that prevents us from asking these kinds of questions over the Web or of receiving essay answers over the Web, other than some students' reluctance to type.

## CONCLUSION

Our experience with examinations on the Web has been positive, and the Pediatrics clerkship director plans to add more images and questions to the database. In the future, Pediatrics would like to move away from a single examination at the end of the clerkship to a series

of self-paced learning modules with short quizzes at the end of each module. An ambitious design such as this would benefit from the strengths of the Web even more than the current implementation.

Based on our experiences with electronic testing on the Web, we recommend this approach to other institutions. The reactions of students and faculty to informal surveys have been almost universally positive. Negative comments have been from those who tend to be uneasy with computer technology in general, and the number of these students seems to be decreasing each year.<sup>17</sup>

A large part of our educational efforts at the ADL are directed towards Web-based tools. We believe many other institutions share this focus and we anticipate a great deal of medical educational software on the Web in the coming years.

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